Where energies make tomorrow

Phenolics

Cumene, Bisphenol A, Isopropyl Alcohol, and Acetone-to-Cumene

Badger Cumene, Bisphenol A (BPA), Isopropyl Alcohol and Acetone-to-Cumene technologies – worldwide standard for high yield, energy efficient, low environmental impact processes

T.EN TECHNIP ENERGIES

As a leader in phenolics technologies, Technip Energies Badger Process Technology is committed to providing our customers best-in-class technologies with our team of dedicated professionals extending our service beyond basic package design, through the entire construction phase and additional support on an as-needed basis after start-up.

Badger Cumene

Badger Cumene technology has gained worldwide acceptance as the standard for production of cumene. Our cumene technology produces a high yield, highly energy efficient, and low environmental impact process. It is easy to operate and maintain and offers low capital and operating costs. Technip Energies and ExxonMobil share a 25-year history of cooperation in the development of catalysts and processes for the production of cumene from polymer grade, chemical grade, and refinery grade propylene.

Since commercialization in 1996, our cumene technology has been licensed 36 times, both for new plants and for the expansion and conversion of plants based on earlier technologies to Badger Cumene technology. The exceptional properties of ExxonMobil's cumene catalysts allow operation with a minimal excess of benzene in the alkylation and transalkylation reactor feeds, reducing capital investment and energy consumption in the reaction and distillation sections of the cumene plant. Decades of commercial operation have demonstrated production of high quality cumene product with long, uninterrupted catalyst cycle lengths.

ALKYLATION

An alkylation reactor system converts benzene and propylene to cumene in the liquid phase. A small fraction of the cumene is further alkylated to polyisopropylbenzenes (PIPB), which will be recovered in distillation and converted to cumene in the transalkylation reactor.

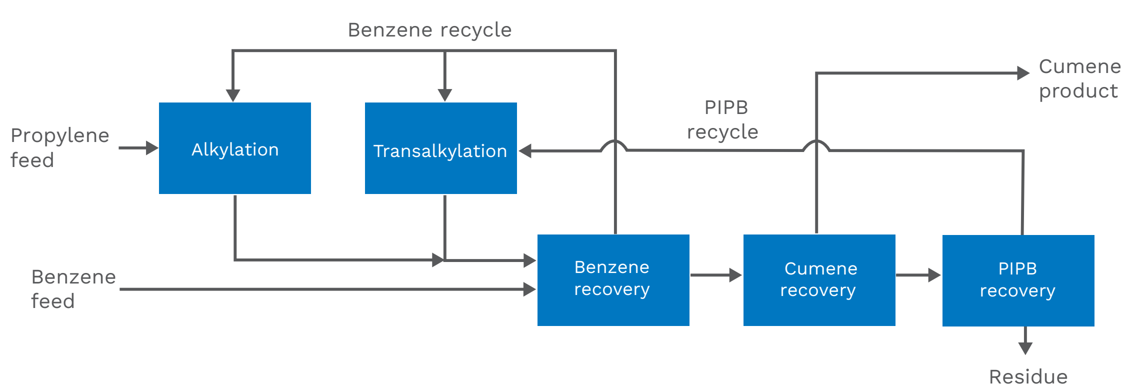
TRANSALKYLATION

A single bed transalkylation reactor converts the small amount of PIPB formed in the alkylator to additional cumene by reaction with benzene in the liquid phase.

PURIFICATION

A simple energy efficient distillation train is used to return excess unreacted benzene to the reactors, recover cumene product, and recycle PIPB to transalkylation.

Cumene process scheme



Cumene technology highlights

LOW OPERATING COST

- Ultra-high (nearly stoichiometric) yields minimize raw material consumptions
- Low B/P and Bz/PIPB ratios minimize utility and power consumptions
- High energy efficiency and seamless integration with downstream phenol and bisphenol A units

LOW CAPITAL INVESTMENT

- Low B/P and Bz/PIPB ratios results in smaller distillation equipment
- Small reactors and catalyst volumes
- Low temperature, pressure, and non-corrosive conditions allows carbon steel construction

Commercial experience

- As of early 2020, plants using our Cumene technology produce over half of the world's cumene capacity having a total installed capacity of more than 10 million metric tons per year
- We have licensed and demonstrated single train capacities as large as 750 KTA
- Our technology can produce high quality cumene from any commercial grade of propylene
- We have successfully supplied cumene to all major downstream phenol processes

The Badger Cumene process is a high yield, high energy efficiency, low environmental impact process that is easy to operate and maintain, allowing for very low production cost.

Our catalyst provider: ExxonMobil

ExxonMobil Catalysts and Licensing LLC (EMCL)'s zeolite catalyst research and development capabilities are unsurpassed within the industry. Supported by basic research activities at its R&D facilities and pilot plant facilities used to screen new catalysts, EMCL is a recognized leader in the development and commercialization of new zeolite catalytic materials. EMCL's commercial catalyst production plants maintain the highest quality control standards. The exceptional characteristics of the cumene catalysts benefit the process as follows:

- The proprietary zeolite catalyst does not age due to oligomerization and coking, resulting in long, uninterrupted commercial catalyst cycle lengths
- EMCL's zeolite catalyst does not require hot benzene washes or special procedures to restore catalyst activity
- The alkylation catalyst is highly selective to monoalkylation, which has allowed commercial operation at design benzene-to-propylene molar feed ratios as low as 1.8-to-1
- The reaction system produces extremely low levels of impurities boiling in the range of cumene, resulting in cumene product purities in excess of 99.97 wt%.

Bisphenol A (BPA)

The Badger Bisphenol A (BPA) technology converts commercial grade phenol and acetone into high-purity BPA suitable for polycarbonate, epoxy resin, and other chemical applications.

BPA process

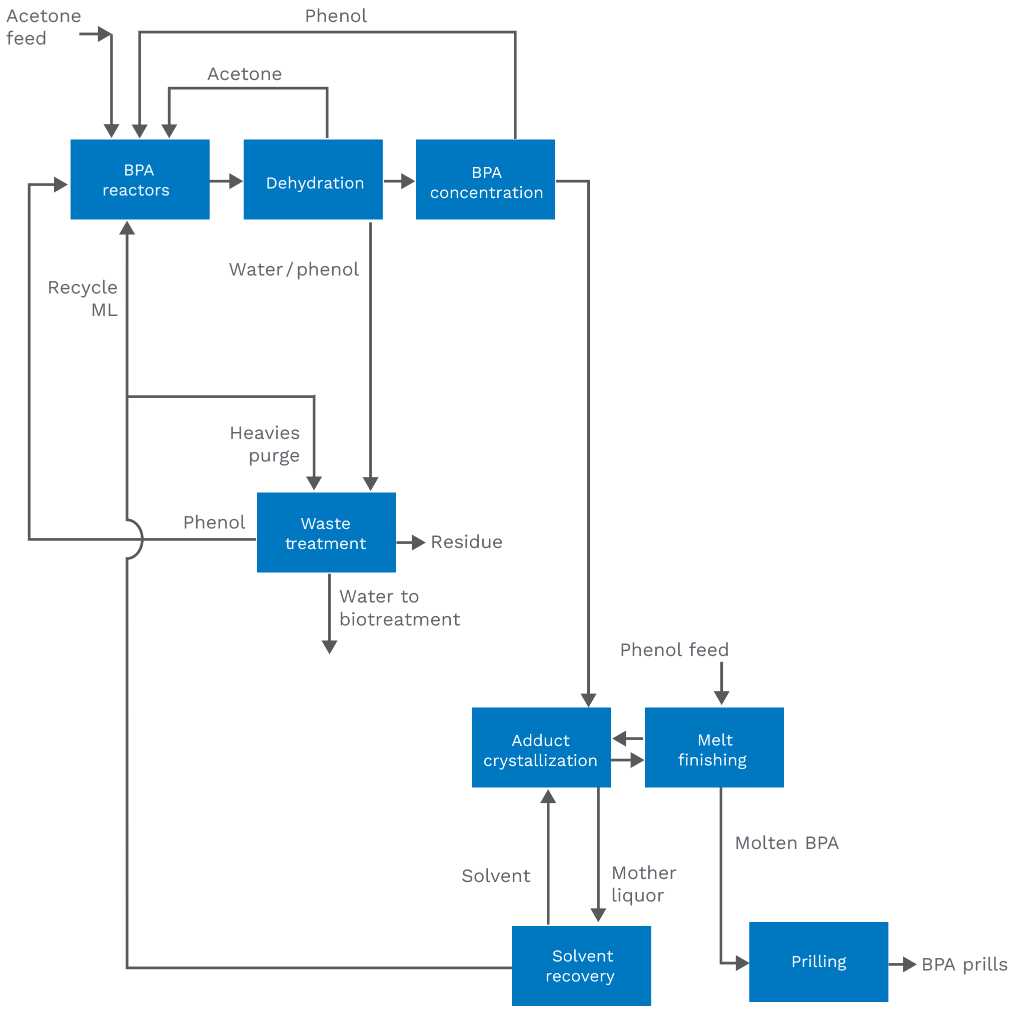
Our BPA technology is based on a technology platform originally developed by Shell Chemical Co. for their plant in Texas which is now owned and operated by Hexion, Inc. The process combines an efficient, low-co st ion exchange resin catalyst system and a proprietary purification technology. With over 3.3 million tons of licensed BPA capacity, the Badger Bisphenol A technology has a proven record of success.

REACTION/DEHYDRATION

Acetone reacts with phenol in a 2-stage reaction section over ion exchange resin catalyst and a homogeneous co-catalyst. The crude reaction product is distilled to recover the co-catalyst and unreacted acetone, to remove co-product water, and to increase the BPA concentration in the product stream.

CRYSTALLIZATION/MELT FINISHING

A proprietary crystallization process separates the desired p,p'-BPA isomer from impurities formed by side reactions. Melt finishing removes and recovers phenol from the crystallization product by vacuum distillation to produce a high-purity p,p'-BPA melt stream while minimizing thermal degradation. The molten BPA can then be solidified in a prill tower or other device.



BPA technology highlights

LOW VARIABLE OPERATING COST

- Superior catalyst economics
- Improved feedstock consumption
- Competitive steam and power consumption

CATALYST PERFORMANCE

- Low-cost ion exchange resin catalyst with proprietary homogenous promoter to boost catalyst productivity and selectivity

SUPERIOR PRODUCT QUALITY

- 99.95% p,p-BPA purity
- Excellent product color
- Globally, the BPA prills from Badger-licensed plants are readily accepted by most polycarbonate (PC) producers, distinguishing Badger BPA technology from that of others. Of note, BPA plants in East Asia utilizing Badger technology have customers that use a variety of PC technologies to produce a full range of grades, including high-end optical grades

Commercial experience

- Demonstrated performance with 10 licensed BPA plants in commercial operation with installed capacity of over 1.35 million tpy
- Single train plant capacities of 60,000 tpy–240,000 tpy
- Technology reference plant operating since 1992
- 98% demonstrated on-stream factor

Acetone-to-Cumene

Badger Acetone-to-Cumene (ATC) technology offers a low capital investment with simple integration into existing cumene plants. The unit's design allows for easy and safe operation with a high reliability and high on-stream time.

ATC Process

For cumene producers seeking an alternative feedstock to propylene, looking to capitalize on the phenol-acetone imbalance that may exist in the market, or looking to maximize profits through arbitrage of the fluctuations in propylene, IPA, and acetone pricing, Badger's ATC technology offers the perfect solution at a low capital investment. Badger ATC technology offers flexibility and can be applied to produce cumene from 100% acetone feed or can be integrated in standard propylene-based cumene plants using partial recycle of acetone from an associated phenol plant.

HYDROGENATION

A nickel catalyzed hydrogenation system converts acetone and hydrogen to isopropanol (IPA).

ALKYLATION

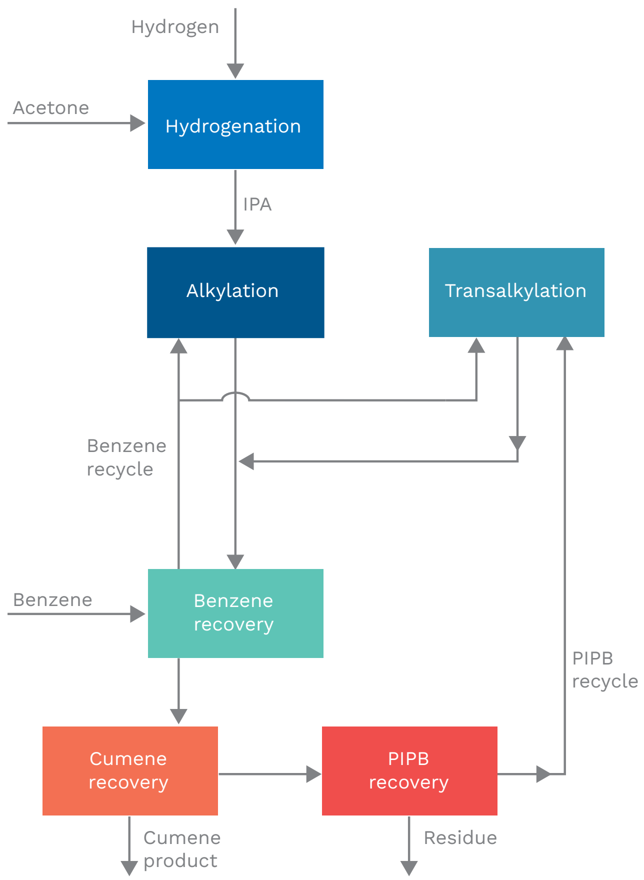
An alkylation reactor system converts benzene and IPA to cumene in the liquid phase. A small fraction of the cumene is further alkylated to polyisopropylbenzenes (PIPB) which will be recovered in distillation and converted to cumene in the transalkylation reactor.

TRANSALKYLATION

A single bed transalkylation reactor converts the small amount of PIPB formed in the alkylator to additional cumene by reaction with benzene in the liquid phase.

PURIFICATION

A simple energy efficient distillation train is used to return excess unreacted benzene to the alkylation and transalkylation reactors, recover cumene product and recycle PIPB to transalkylation.



ATC technology highlights

LOW OPERATING COSTS

- Ultra-high (nearly stoichiometric) yields minimize raw material consumptions
- The alkylation catalyst used can tolerate high water concentration, requiring less circulation

LOW CAPITAL INVESTMENT

- Low benzene to acetone and Bz/PIPB ratios results in smaller reaction and distillation equipment
- Small catalyst volumes
- Low temperature, pressure, and non-corrosive conditions allows carbon steel construction

SUPERIOR TECHNOLOGY

- ExxonMobil's proprietary zeolite catalyst does not age due to oligomerization and coking, resulting in long, uninterrupted commercial catalyst cycle lengths
- High yield – nearly as high as propylene-based zeolite process

Our alkylation catalyst provider: ExxonMobil

ExxonMobil Catalysts and Licensing LLC (EMCL)'s zeolite catalyst research and development capabilities are unsurpassed within the industry. They are the leader in the development of new zeolite catalytic materials supported by extensive R&D facilities. EMCL's commercial catalyst production plant maintains high quality control standards.

Isopropyl Alcohol Technology

Badger Isopropyl Alcohol (IPA) technology produces high purity isopropyl alcohol, while offering low capital and operating costs.

Crude IPA is produced as an intermediate stream in Badger's Acetone-to-Cumene (ATC) technology via the hydrogenation of acetone. Typically, in the ATC process, the IPA is then alkylated with benzene in a reaction step to produce cumene. However, for the process that produces IPA, the IPA intermediate is purified and becomes the final product.

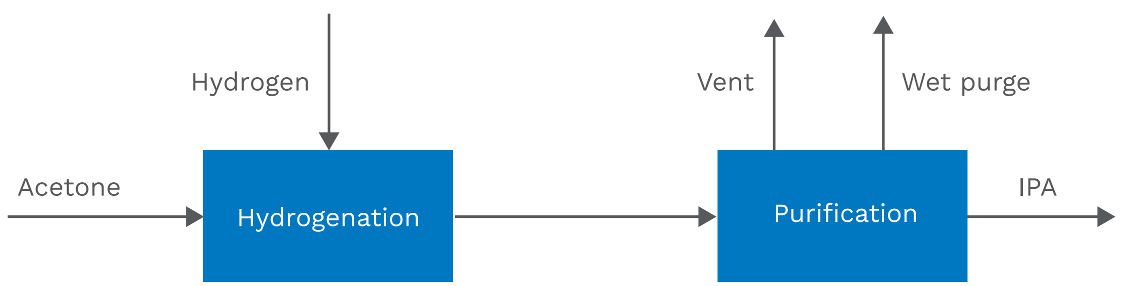
Hydrogenation

A hydrogenation system converts acetone and hydrogen to isopropyl alcohol (IPA). The hydrogenation reactor operates in the mixed phase, trickle bed flow regime. Acetone and hydrogen feedstocks enter the reactor and react on a supported nickel catalyst. The effluent from hydrogenation flows to downstream processing for purification of the IPA product.

Purification

The feed to purification is a stream containing primarily isopropyl alcohol and water at a composition close to their low boiling azeotrope. The product separation is accomplished using simple distillation, with fewer columns than other technologies. The product is a commercial grade IPA product that conforms to the ASTM D-770 specification. There is also a small vent stream and a small wet purge leaving the purification system.

IPA process



Operating flexibility

- IPA unit can be integrated into existing cumene-phenol plants to produce a cumene product if integrated with IPA alkylation
- Can be a standalone IPA unit producing commercial grade IPA product

Low capital investment and operating cost

- Small catalyst volume in hydrogenation reactor
- Simple distillation scheme to purify the IPA product
- High yield and low energy consumption

Commercial Experience

Badger's IPA process has been licensed five times for a total licensed capacity of 260 KTA. The first unit started up successfully in early 2020, a second unit is under construction and scheduled for startup later in 2020 and three units are in design.

Technip Energies Badger Process Technology

Dana Johnson
Dana.Johnson@technipenergies.com
+1 617 748 7220

Kenneth Potochnik
kenneth.potochnik@technipenergies.com
+1 617 748 7272

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